The values of Q are strictly *equivalent* to each other in point of activity. The author believes that a is commensurate with the elective function of chemical attraction, first discovered by Bergman. He terminates the memoir with a reference to some well-known instances of chemical action (such as that of argentic nitrate on a mixture of aqueous potassic chloride, bromide, and iodide), as serving to bestow a presumptive generality on his principal conclusions.

V. "On the relative Duration of the Component Parts of the Radial Sphygmograph Trace in Health." By A. H. GARROD, of St. John's College, Cambridge. Communicated by Dr. GAR-ROD. Received April 23, 1870.

The graphic method of representing the various phenomena occurring in the body during life, which has been so much developed by MM. Marey and Chauveau of Paris, has placed within our reach great facilities for obtaining an accurate knowledge of the relations, in point of time, of mutually dependent physiological events, and the sphygmograph has become, among others, an instrument familiar to most interested in science.

By means of this instrument, a detailed and truthful record can be easily obtained of the modifications in the diameter of any superficial artery, and, as usually constructed, it is intended to be applied to the radial at the wrist.

The traces to be referred to were taken with one of Marey's instruments, as made by Breguet. The recording paper ran its whole length, $4\frac{2}{5}$ inches, in seven seconds, and thus, by counting the number of pulse-beats in each trace, and multiplying the number thus obtained by 8·57143, the rate of the pulse at the time the trace was taken was easily found.

The lever-pen was of thin steel, sharply pointed, and it recorded by scratching on highly-polished paper previously smoked.

It is now generally agreed that in each pulsation of the radial sphygmograph trace, the main rise is the effect of the contracting ventricle sending blood into, and thus filling, the arterial system.

This rise is followed by a continuous fall when the pulse is quick, but when slow, its continuity is interrupted by a slight undulation, convex upwards.

The major fall is followed by a secondary rise, not so considerable as the main one, but more marked than any other, and this secondary rise is evidently due to the closure of the aortic valves preventing further flow of blood heartwards.

The two points therefore, the commencement of the primary and of the secondary rise, may be considered to mark the beginning of the systole of the heart, and the closure of the aortic valve respectively, as far as they influence the artery at the wrist ; and the interval between these two events may be called the *first* part of the arterial sphygmograph trace,

while the interval between the beginning of the secondary rise and that of the succeeding primary one constitutes the second part of the same trace.

In 1865, Prof. Donders* published the results of experiments to determine the relative duration of the first and second part of the cardiac revolution with different rapidities of movements of the heart, taking as his data the commencement of the first and second sounds respectively, and he came to the conclusion that, though the second part varied with the rapidity, the first part was almost constant in all cases.

On commencing work with the sphygmograph, the author came to the same conclusion with regard to the trace at the wrist, but, on improving his methods of observation, he has arrived at a different result.

The best means of insuring an accurate measurement of any sphygmograph trace is to project all the points desired to be compared on to one straight line, and this is done by fixing the trace on to a piece of board, which has another pointed lever attached to it, with relations similar to those of the lever and recording apparatus in the original instrument. By this means lines can be scratched on the trace similar to those which would be produced by the instrument itself if the watch-work were not moving, and a result, as shown in Plate II. fig. 1, can be easily produced.

The reason why this means has to be employed is, because the lever in the sphygmograph moves in part of a circle, not directly up and down.

The ratio between the length of the first part of each pulse-beat in a trace and that of the whole beat was measured with a small pair of compasses, and from these the average was obtained, which thus eliminated, in a great degree, the variations produced by the respiratory movements, and also some of the clock-work imperfections.

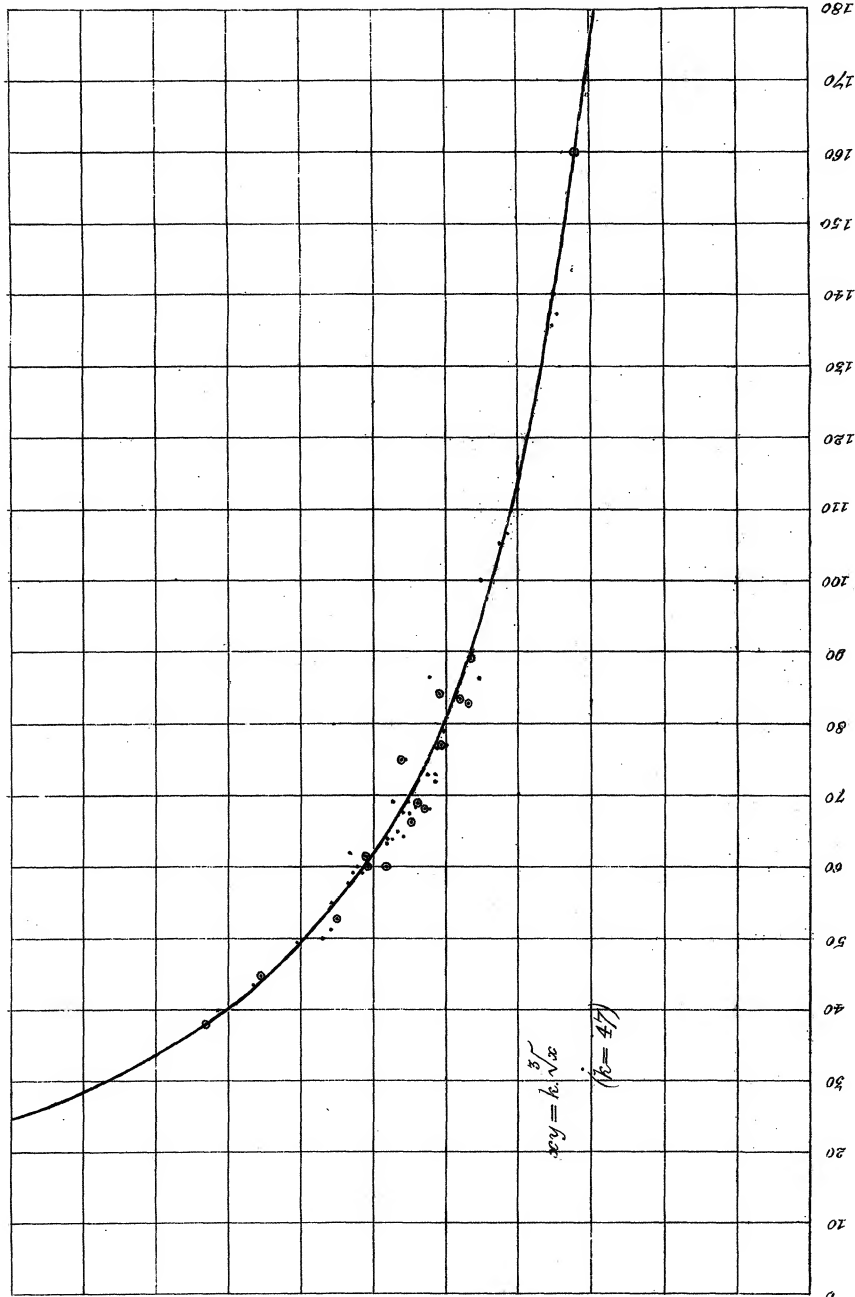For example, in fig. 1, the ratios in the several beats are :—

$$1 : 1 \cdot 8$$
$$: 1 \cdot 725$$
$$: 1 \cdot 725$$
$$: 1 \cdot 775$$
$$: 1 \cdot 725$$
$$: 1 \cdot 7$$
$$: 1 \cdot 725$$
$$: 1 \cdot 775$$
$$: 1 \cdot 8$$
$$: 1 \cdot 775$$
$$: 1 \cdot 675$$
$$: 1 \cdot 75$$
$$: 1 \cdot 75$$
$$: 1 \cdot 725$$

with an average of $1 : 1 \cdot 7443$.

* " On the Rhythm of the Sounds of the Heart." By F. C. Donders. Translated in the ' Dublin Quarterly Journal of Medical Science,' Feb. 1868, from the 'Nederlandisch Archief voor Genees- en Natuurkunde,' Utrecht, 1865.

Garrod

$$xy = k.\sqrt[3]{x}$$

$$(k = 47)$$

Ratio of
1st part
of pulse
to whole
beat.

Rate of
pulse
in a
minute.

W. West imp.

W. H. Wesley lith

Again, in fig. 2, the ratios are :—

$$1 : 3\cdot8$$
$$: 3\cdot775$$
$$: 3\cdot8$$
$$: 3\cdot825$$

with an average of $1 : 3\cdot8$.

Calling the rate of the pulse x, and the number of times the *first* part is contained in the whole beat y, xy equals the number of times that the *first* part is contained in a minute, and $\dfrac{1}{xy}$ equals the part of a minute occupied by the *first* part of each pulse-beat.

From several observations, it was found that xy increases with x, not directly as it, but as its cube root, consequently the following equation finds xy in terms of x,

$$xy = k \sqrt[3]{x},$$

k being a constant, equal to 47 (about).

For instance, in fig. 1, $x = 137$, $y = 1\cdot7443$;
and in fig. 2, $x = 44$, $y = 3\cdot8$;
and $137 \times 1\cdot7443 = 238\cdot9691$,
                  $44 \times 3\cdot8 = 167\cdot2$;
and $238\cdot9691 : 167\cdot2 :: 1\cdot43 : 1$,
and $\sqrt[3]{137} : \sqrt[3]{44} ::$
                  $= 5\cdot155 : 3\cdot54 :: 1\cdot456 : 1$,

which shows that in these individual cases xy varies, within the limits of experimental error, as the cube root of x.

If this statement of the ratio of the *first* part of the trace to the whole beat is a correct one, a knowledge of the rapidity of the pulse alone is sufficient to enable the length of the *first* part to be found by multiplying the cube root of the rapidity by the constant quantity 47.

Thus, supposing the pulse beats 64 times in a minute, the cube root of 64 being 4, $4 \times 47 = 188$, and the length of the first part of the beat ought to be $\frac{1}{188}$ of a minute. In one case with $x = 64$, xy was found to be $185\cdot75$, and in another with $x = 63\cdot5$, $xy = 181\cdot77$, both numbers which agree closely with the requirements of the equation.

With $x = 140$, and therefore $\sqrt[3]{x} = 5\cdot2$,

$$5\cdot2 \times 47 = 244\cdot4 ;$$

and therefore the first part $= \frac{1}{244} - \frac{1}{245}$ of a minute ; in a pulse of that rapidity xy was found $= 242\cdot9$.

To save the trouble of extracting the cube root for any rapidity, these facts have been thrown into a coordinate form in the accompanying Table, and the observations on which the formula is based are represented by dots on their proper coordinates, the calculated curve, with $k = 47$, being represented by a continuous line.

Since the above equation was worked out, a great many other observa-

tions have been made, several of which are recorded on the Table, and in health no cases have been found which depart from the curve more than those indicated on it.

The observations made on the author are represented by simple black dots, those made on others are encircled by a ring ; great size of a dot indicates that more than one independent observation has produced exactly similar results.

In none of the cases have measurements been made after violent exercise. Differences in the height and age of the subjects experimented on have not been found to produce any appreciable effect.

The trace from infants has not been examined.

From the equation $xy = \sqrt[3]{\bar{x}} \cdot k$ the length of the *second* part of the pulse trace may be represented in terms of x, as $\dfrac{k - \sqrt[3]{x^2}}{x \cdot k}$; and as from the nature of y it cannot be less than unity (no pulse having been seen with two contractions or more between two successive closures of the aortic valve), the limit of cardiac rapidity may be deduced to be 322 in a minute ($k = 47$); but it is scarcely probable that pulses of such a rate could remain so sufficiently long to be counted.

In many cases of disease implicating the circulatory system, the equation given above indicates that the duration of the *first* part of the heart's action is not normal; thus, in a boy suffering from typhoid fever, on the second day after the pyrexia had ceased, and when the temperature was below the normal, xy was found $= 225 \cdot 25$, where $x = 60$, which differs from the equation

$$\sqrt[3]{67} \times 47 = 190 \cdot 82,$$

which shows that the length of the *first* part is considerably too short in the former. In the same case, three days later, the patient rapidly improving, with $x = 56 \cdot 5$,

$$xy = 188,$$

which is much nearer the calculated normal result, $180 \cdot 5$, than on the former occasion, the trace keeping pace with the other physical changes.

It is probable that many other imperfections in the circulatory system can be similarly indicated, and it has been shown above with what facility a diagnosis may be arrived at.

VI. " Spectroscopic Observations of the Sun."—No. VI.
By J. Norman Lockyer.   Received April 27, 1870.

The weather lately has been fine enough and the sun high enough during my available observation-time to enable me to resume work.

The crop of new facts is not very large, not so large as it would have been had I been working with a strip of the sun, say fifty miles or a hundred miles wide, instead of one considerably over a thousand—indeed, nearer two thousand in width ; but in addition to the new facts obtained, I have